UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF.

SELECTED ANNOTATED BIBLIOGRAPHY ON SEDIMENTATION AS RELATED TO SOIL CONSERVATION AND FLOOD CONTROL

Compiled by

Carl B. Brown and Farrell F. Barnes

Sedimentation Division
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INTRODUCTION

This annotated bibliography has been prepared in response to requests from soils experts, engineers, and other technicians in the Soil Conservation Service and other branches of the Department of Agriculture. These requests have emphasized the need for source material that would give a well-rounded perspective of the field of sedimentation as it relates to the other technical activities of the Service and Department in soil and water conservation and flood control. In recent months the necessity of developing sedimentation investigations as an integral part of the coordinated flood-control surveys has made it especially desirable to compile such a bibliography.

Sedimentation as it relates to the interests of the Service and Department is a broad field, not restricted to one science, but having roots in geology, soil science, hydrology, engineering, and to a lesser extent in several others. For this reason the number of publications touching on some phase of sedimentation is very large, yet the number of publications that cover even an appreciable part of the whole field is extremely limited. Any reader, therefore, to acquire a well-rounded "talking knowledge" will find it necessary to read or review a comparatively large number of publications. For example, Twenhofel's "Treatise on Sedimentation" considers the subject in its geologic aspects; Stevens' paper, "The Silt Problem", discusses the relation of sedimentation to engineering works; Eakin's "Silting of Reservoirs" is a detailed discussion of the relation of sedimentation to damage to reservoir-storage developments. Other papers treat of the relation of sedimentation to agricultural productivity of bottom-land soils, stream-bank erosion, silting of drainage ditches, and many other problems.

From hundreds of articles on one or another aspect of the sedimentation problem, the compilers of this bibliography have attempted to select one or more papers on each of the more important phases of the subject, and all papers that cover several phases, which might be termed comprehensive. Especially have the needs of personnel engaged in flood-control surveys, and the particular problems which they face, been kept in mind.

Approximately half of the titles in this bibliography are included in "Bibliography on Soil Erosion and Soil and Water Conservation", compiled by Stanley H. Gaines (U. S. Dept. of Agriculture Miscellaneous Publication No. 312, October 1938). For

most of these titles the abstracts used in that publication are copied here. On many of the remaining titles, abstracts used are those prepared by personnel of the Works Progress Administration official Project No. 765-97-3-5 which is sponsored by the Sedimentation Division and is devoted to sedimentation literature research.

Inasmuch as the card abstract records of sedimentation literature being compiled by the Sedimentation Division with the assistance of the Works Progress Administration (see Technical Letter Sed-10) are still far from complete, some important papers are probably omitted here, and some of the selections may not represent the best or latest available in that phase of the subject. Nevertheless it is believed that this selection will direct the reader to most of the currently important problems in sedimentation. For those interested in pursuing more extensively special aspects of the subject the files of the Sedimentation Division in Washington are available.

BIBLIOGRAPHY

(1) Advance Reports on Sedimentation Surveys.
U. S. Soil Conserv. Serv. SCS-SS-1 to 33. 1936-1939.
(Mimeographed.)

A series of reports on detailed sedimentation surveys in various parts of the United States. Most of the reports deal with reservoir sedimentation and give a brief description of the reservoir and its drainage area, discuss the character, distribution, and origin of the sediment deposits, summarize the quantitative results of the survey, and present such conclusions and recommendations for reduction of silting rates as are suggested by the study. The following reports have been issued to date:

SS-1	Lake Spavinaw	Spavinaw, Okla.
SS-2	Instructions for Reservoir Sedimentation Surveys.	
SS-3	Lake Booneville	Booneville, Ark.
SS-4	Lake Harris	Tuscaloosa, Ala.
SS-5	Lake Purdy	Birmingham, Ala.
SS-6	Buck, Byllesby, Fields, and Washington Mills Reservoirs	New River, Va.
SS-7	Lake Sapulpa	Sapulpa, Okla.
SS-8	Lake Taneycomo	Branson, Mo.
SS-9	Lake Bennett	Conway, Ark.
SS-10	High Rock Reservoir	Salisbury, N. C.
SS-11	Bayview Reservoir	Birmingham, Ala.
SS-12	Lake Decatur	Decatur, Ill.
SS-13	Lay Reservoir	Clanton, Ala.
SS-14	Lake Bracken	Galesburg, Ill.
SS-15	West Frankfort Reservoir	West Frankfort, Ill.
SS-16	Lake Calhoun	Galva, Ill.
SS-17	Lakes Crook and Gibbons	Paris, Tex.
SS-18	Ottawa County State Lakes	Bennington, Kans.
SS-19	Black Canyon Reservoir	Emmett, Idaho.
SS-20	Hayes Lake	Hayes, S. Dak.
SS-21	Baker Reservoir	Baker, Mont.
SS-22	Mission Lake	Horton, Kans.
SS-23	Wellfleet Reservoir	Wellfleet, Nebr.
SS-24	Lake Olathe	Olathe, Kans.
SS-25	Lake Eldorado	Eldorado, Kans.
SS-26	Hurley Lake	Gettysburg, S. Dak.
SS-27	Bennett Irrigation & Silting Basin	Wilsoncreek, Wash.
SS-28	Burlington Reservoir	Burlington, N. C.

(1) Continued.

SS-29 Barcroft Reservoir.....Alexandria, Va.
SS-30 Franklinton Reservoir.....Franklinton, N. C.
SS-31 Burnt Mills Reservoir.....Silver Spring, Md.
SS-32 York River Estuary.....West Point, Va.
SS-33 Greenbelt Lake.....Greenbelt, Md.

(2) Allis, John A.
How Silt Is Measured on Project Streams. Soil Conserv. 1: 5-6, illus. August 1935.

Describes methods for measuring silt at Stillwater Creek project in Oklahoma.

(3) Anonymous.
Sand Trap for Self Cleaning of Canals and Streams. Pub. Works 65: 16. November 1934.

This article describes three different types of sand traps developed by R. L. Parshall, by means of which a small part of the stream can be diverted through them to carry out of the main stream a concentrated load of sand, silt, and debris.

(4) ____
Engineering Investigations (Silt Observations at Yuma Gaging Station). Reclam. Rec. 8: 240-241, illus. 1917.

Records of 4,000 silt observations at Yuma gaging station on the Colorado River, made by the Reclamation Service since 1909, were compiled. Great variation in cross section of channel noted. Summarized data on maximum percentage of silt at various discharges; maximum and mean percentage of silt by weight; weight and specific gravity of wet and dry deposited silt. Compares the quantity and weight of silt carried by the Colorado with that of other streams.

(5) ____
Silt Problem of River Reservoirs. Engin. News-Rec. 84: 145. 1920.

Notes average annual storage loss of several reservoirs (Zuni Reservoir and Lake McMillan, N. Mex., and Lake Austin, Tex.); discusses silt content of the Rio Grande, Bonita Creek, Moencopi Wash (Ariz.), and the Kaw River, Kans. The large amount of silt carried (more than 80 percent in some cases) has been taken to indicate the great eroding power of floods.

(5) Continued.

Although this may apply to large streams it does not seem to apply to the flashy streams of the Southwest, where a smaller volume of run-off may carry a greater quantity of silt. It is suggested that this may be explained by the dryness, and greater erodibility, of the ground during periods of low run-off as compared with periods of greater run-off when the ground is moist and not so easily eroded.

Discusses feasibility of various methods of removing silt from Zuni Reservoir. Riprapping of shores and placing large sluices in the dam considered of doubtful utility. The only feasible method believed to be the use of an automatic suction dredge with floating pipe line attached to the lowest outlet in the dam; and even this would involve difficulties during dry seasons when the silt would have to be discharged into the canal to prevent wastage of water.

(6) Anonymous.

Silt and Silting Basins on Drainage Works. Engin. News-Rec. 92: 488-489, illus. 1924. (Abstract of paper read before the National Drainage Congress by Roy N. Towl.)

Discusses the design of settling basins on drainage projects, with special reference to Hill Creek settling basin in the Burt-Washington drainage district at Herman, Nebr., in which the principle of water-spreading is used. This provides for deposition on farm land of all silt that would otherwise clog canals carrying away overflow water. Notes damage by silting of ditches in Fremont and Woodbury Counties, Iowa, necessitating raising of railway grades and bridges.

(7) Ashe, W. W.

Financial Limitation in the Employment of Forest Cover in Protecting Reservoirs. U. S. Dept. Agr. Bull. 1430, 34 pp., illus. 1926.

"The influence of the forests in protecting reservoirs used for power purposes varies in different regions with the differences in soil, surface, and precipitation. In this bulletin those regions in which this influence is most important ...are pointed out, also the value of forest cover and the financial limitations in its employment to prolong the utility of a reservoir are discussed."

(8) Ashe, W. W.
Soil Erosion and Forest Cover in Relation to Utilization of Water Power, with Special Reference to the Southeast. Engin. World 23: 73-75. August 1923.

The silting of reservoirs is discussed as "a condition produced very largely and in many cases entirely through exposure of the naked soil--the removal of the protective cover of forest, with its litter and humus." Such erosion need not take place; a reservoir site when developed should have such protection as will insure its permanence. A summary on surface conditions, rainfall, and amount of solid matter carried by streams in different sections of the United States is given.

(9) ———
Special Relations of Forest to Rivers in the United States. U. S. Inland Waterways Comm. Prelim. Rept. 1908: 514-534. 1908.

Discusses varying influences of forests upon stream flow in six different river groups of the United States. The groups are: Rivers of the Northeastern States and the Great Lakes region; rivers of the Middle Atlantic Coast region; rivers of the Appalachians; rivers flowing from the eastern and southern slopes of the Rocky Mountains; Sacramento and San Joaquin Rivers; and the Columbia Rivers. Considerable data on erosion and sedimentation for each group are given.

(10) Bailey, R. W., Forsling, C. L., and Beecraft, R. J.
Floods and Accelerated Erosion in Northern Utah. U. S. Dept. Agr. Misc. Pub. 196, 21 pp., illus. 1934.

"The studies reported in this publication were conducted by the Intermountain Forest and Range Experiment Station in cooperation with the Utah Experiment Station and the geology department of the Utah State Agricultural College. The purpose is to present geologic evidence of flood damage and to point out that the recent floods in northern Utah constitute abnormal run-off and accelerated erosion, thereby marking a radical change from the normal rate of gradation of the present geologic epoch and climate. Evidence also is presented tending to show that this condition can be attributed chiefly to the depletion of the plant cover on the watersheds of the drainages involved."--Expt. Sta. Rec. 72: 541. 1935.

(11) Bates, E. M.
Regrassing Silted Areas. New Zealand Jour. Agr. 56: 314-318. illus. 1938.

Discusses methods of sowing grass seed on freshly silted pasture land in New Zealand and Australia. The most important point is to get the sowing done as soon as possible, to give the seed a chance to germinate before the silt dries and bakes.

(12) Bennett, H. H.
Economics of Preventing Soil Erosion. Agr. Engin. 10: 29, 1-296, illus. September 1929.

Studies in precipitation and soil loss in Texas, Missouri, North Carolina, and northeastern Kansas are described. The relation of erosion to soil type, stratigraphic soil features and erosion, and the character of soil cover are discussed in detail. "There is abundance of evidence that the estimate of 1,500,000,000 tons of soil material annually washed out of our American fields is exceedingly low. Even so, the amount of plant food contained in this is about 126,000,000,000 pounds, on the basis of the average analyses of 389 samples of surface soil collected throughout the country."

(13) ____
Studies on Soils Which Bear on Sedimentation. Natl. Research Council, Reprint and Cir. Ser. 85: 80-83. 1928.

"This is a brief statement regarding the work of the Bureau of Chemistry and Soils of the United States Department of Agriculture, especially on soil erosion as related to sedimentation."--Expt. Sta. Rec. 60: 713. 1929.

(14) Bissell, C. A.
Silt Conditions at Elephant Butte Reservoir. New Reclam. Era 21: 198-199. October 1930.

Discusses sources of silt and gives data on percentages of silt in suspension at San Marcial, N. Mex. The effect of the 1929 flood on sedimentation is also discussed.

(15) Breazeale, J. F.
A Study of the Colorado River Silt. Ariz. Agr. Expt. Sta. Tech. Bull. 8: 165-185. 1926.

Contents: Introduction (a description of the Colorado River and its "silt"); The Silt-Carrying Capacity of a River as Influenced by Colloidal Dispersion; Classification of the Silt Load; The Dispersion of Soil Colloids; Replaceable Bases in Colorado River Silt; Physical Character of the Silt; Quality of the Colorado River Water; Absorption of Alkali by Colloids; Effect of the Hydroxides of Sodium, Potassium, and Calcium in Flocculating Colorado River Silt; Effect of Gypsum upon the Flocculation of Colorado River Silt; Effect of Calcium Sulphate upon Colorado River Silt in the Presence of Small Amounts of Sodium Carbonate; Flocculation of Colorado River Silt at Flood and at Low Water; Effect of Neutral Sodium Salts upon Colorado River Silt; Summary.

(16) Brown, C. B.
Protecting Bottomlands from Erosional Debris: A Case History. Soil Conserv. 3: 93-96, illus. October 1937.

Describes and outlines the history of a debris basin constructed to check the deposition of erosional debris from a tributary valley over rich bottom lands along the Missouri River in Doniphan County, Kans.

(17) ___
Rates of Silting in Representative Reservoirs throughout the United States. Amer. Geophys. Union Trans. Ann. Meeting 18: 554-557. 1937.

Summarizes studies of reservoir silting by the Soil Conservation Service. These studies "are providing an accurate basis for planning long-term erosion-control programs...", and the "resulting data should...prove of much value...in reservoir-planning, in design of silt-prevention works, and in a wide range of hydrologic studies."
Silting conditions in various parts of the United States and in specific reservoirs are outlined. In conclusion the probable useful life of American reservoirs is summarized.

(18) Bryan, Kirk.
Historic Evidence on Changes in the Channel of Rio Puerco, a Tributary of the Rio Grande in New Mexico. Jour. Geol. 36: 265-282, illus. 1928.

"The Rio Puerco, a tributary of the Rio Grande in New Mexico, has deepened and widened its channel, or arroyo, since the settlement of the region. This process of accelerated erosion still continues. Historical evidence, largely the notes and maps of government land surveyors, is cited to show that the cutting began between 1885 and 1890. The deepening of the arroyos has decreased the agricultural and grazing value of the country, resulting in the abandonment of six small towns and numerous ranches. The coincidence between the introduction of large numbers of stock and the cutting of arroyos indicates that overgrazing precipitated this form of destructive erosion. The ultimate cause, not completely discussed in this paper, appears to lie in cyclic fluctuations in climate."

(19) ____ and Robinson, H. F.
Erosion and Sedimentation on the Zuni Watershed, New Mexico. Amer. Geol. Soc. Bull. 39: 158-159. 1928.

The Zuni Dam, built in 1904-7, created a reservoir having a capacity of 15,811 acre-feet. In the 22 years since 1906 sediment has filled the reservoir to the extent of 69 percent of its original capacity. "Most of the silt comes from the open valleys of a broad syncline of Cretaceous rocks at the foot of the mountains. Here the production of rock waste has always been large, but it has since about 1880, been much accelerated by the erosion of a deep and ever-widening channel or arroyo in the broad valley floors..." The rapid filling of Zuni Reservoir was checked in 1923 by measures designed to control excessive erosion.

(20) Buck, Sir Edward Charles.
The Applicability to India of the Italian Method of Utilizing Silt. Jour. Soc. Arts, May 31, 1907, pp. 734-743.

A historical outline of information on the use of silt in building up and improving land (colmatage) in various countries, particularly Italy, and describes areas in India where this method may be used economically.

In a discussion of this paper (pp. 746-747) R. B. Buckley comments on the quantity of silt in Indian rivers and canals

(20) Continued.
and refers to several areas in India that have been reclaimed by silt. He also refers to canals in India, Egypt, and France and notes costs of canal construction and maintenance.

(21) Classen, A. G.
Practical Aspects of Flood Control and Reclamation of Overflowed Lands. State of Texas Reclam. Dept. Bull. 27: 1-80, illus. 1935.

"This treatise has been written primarily as a brief discussion of flood control and as a source of pertinent information for those interested in the development of flood control and prevention projects on the smaller rivers and streams. The principal part of the discussion treats with the proper design of floodways, channels, and interior drainage of levee improvement districts, and attempts to point out the chief reasons for errors and mistakes most common to this type of public improvement and methods of avoiding them."

(22) Connaughton, M. P.
Preliminary Notes on Reservoir Studies in the Great Plains States. Soil Conserv. 3: 232-233, illus. February 1938.

Summarizes the results of sedimentation surveys of 10 reservoirs in the Northern Great Plains States. Shows that the rate of sedimentation is a minimum measure of the rate of soil loss in the watershed. Points out the effect of the capacity-inflow ratio on the rate of silting, and discusses the effect of climate on the rate of silting in Great Plains reservoirs.

(23) Cooperrider, C. K., and Hendricks, B. A.
Soil Erosion and Stream Flow on Range and Forest Lands of the Upper Rio Grande Watershed in Relation to Land Resources and Human Welfare. U. S. Dept. Agr., Tech. Bull. 567, 83 pp., illus. 1937.

Partial contents: General Description of the Upper Rio Grande Watershed; Land Resources; Striking Evidence of Accelerated Erosion; Destructive Effects of Accelerated Runoff; Causes of Deterioration of Range and Forest Lands; Source of Destructive Flood Waters and Silt; Vegetation-Erosion Relationships; Soil Erosion in Relation to Range

(23) Continued.
Values; The Colorado Part of the Watershed; Solution of the Watershed Problem; The Immediate Need.
Literature Cited, pages 87-88.

(24) Corfitzen, W. E.
Retrogression below Boulder Dam. Reclam. Era 27: 240. 1937.

Desilted water from the lake, 2 years after closure of Boulder Dam, transports particles with average diameter of 0.394 inch, compared with 0.0098 inch at time of closure. Degradation is at a maximum of 12.5 feet 2 miles below dam, averages 6.7 feet in the first 8 miles, and ceases 50 miles below dam. River carries 3 times as much silt at point 237 miles farther downstream, indicating further pick-up of finer material no longer available within 50 miles of dam. Retrogression is an important factor in design of irrigation intake structures and power-plant draft tubes.

(25) Davis, A. P.
Measurement of Sediment. U. S. Geol. Survey Water-Supply Paper 47: 15-18. 1901.

Discusses two methods of measuring the amount of sediment held in suspension by streams in Arizona. Necessary equipment is described.

(26) Dole, R. B., and Stabler, H.
Denudation. U. S. Geol. Survey Water-Supply Paper 234: 78-93, illus. 1909.

"The accompanying tables present estimates of the rate of denudation in the United States. The figures show the rate at which the earth's crust is being moved as solid particles carried in suspension by streams and as matter carried in aqueous solution. The first table is a summary of the estimated denudation for the whole United States and for the primary drainage basins; the other tables contain detailed estimates for smaller areas. The map indicates graphically the rates of denudation in different parts of the country." The methods of computation and their probable accuracy are considered. "The estimates reveal that the surface of the United States is being removed at the rate of thirteen ten-thousandths of an inch per year, or 1 inch in 760 years."

(27) D'Roahn, W.
The Silting Up of Reservoirs and Canals and Some Methods for Preventing Same. Engin. Cont. 35: 56-58, illus. January 11, 1911.

Summarizes silting studies of LaGrange Reservoir, Calif., and Lake Austin, Tex., to illustrate the seriousness of reservoir silting in the United States.
Outlines, under two heads, several methods of delaying the destruction of reservoirs by silting (1) silt removal and (2) prevention of silting. Describes designs and methods used in Spanish and Mexican dams to remove silt, and outlines several schemes designed to prevent silt from entering irrigation systems.

(28) Eakin, H. M.
Influence of Deforestation upon Stream and Valley Resources. Jour. Forestry 34: 983-987. November 1936.

Previous studies and fluvial aspects of this problem are considered together with the influence of deforestation through accelerated erosion. "It is with regard to these fundamental problems of soil conservation that the present program of sedimentation and hydraulic studies of the Soil Conservation Service has been laid."

(29) ___
Meeting the Menace of Overflow Waters. Soil Conserv. 1: 5-6. January 1936.

"Comprehensive flood control includes not only the simple confinement and guidance of waters but control of erosion and the transportation and redistribution of sediment as well."

(30) ___
Silting of Reservoirs. U. S. Dept. Agr. Tech. Bull. 524, 142 pp., illus. 1936.

Beginning with a discussion of the economic and physical aspects of the reservoir-silting problem, this bulletin reviews previous silting investigations in the United States, and then presents the results of detailed sedimentation surveys, made by the Soil Conservation Service in 1934-35, of six important water-supply lakes and one major power reservoir in the southeastern United States, five water-supply lakes in the southern Great Plains area, and two

(30) Continued.
large irrigation reservoirs in the Southwest. Results of reconnaissance studies of many additional reservoirs in the southeastern, south-central, and southwestern parts of the United States are also given. These investigations revealed that "silting of reservoirs is a practical problem of the first order of importance in all three regions, wherever accelerated erosion is in force."

(31) Eakin, H. M.
The Twin Problem of Erosion and Flood Control. Reprinted from Amer. Geophys. Union Trans. Ann. Meeting 17: 436-439. 1936.

This paper deals with changes in water and sediment output from upland areas, and reduction of levee freeboard due to loss of overbank area.

(32) Editor.
Silt in Water Works Reservoirs. Water Works Engin. 90: 45-46. January 1937.

Series of letters to Round Table Editor from superintendents and managers of municipal water works on silting in reservoirs. Silting conditions and methods of prevention are discussed. Silt as a source of bad odor and taste in drinking water, as well as reduction of storage capacity, is noted. General description of silt control by tree planting, grass and crop planting, riprapping, and small dams of sheet-steel piling.

(33) Ellis, M. M.
Erosion Silt as a Factor in Aquatic Environments. Ecology 17: 29-42. January 1936.

Discusses the effect of silt on aquatic life, on the basis of observations at more than 700 stations of the Mississippi-Ohio-Missouri system and other interior waters. Laboratory experimental work was carried on at Bureau of Fisheries laboratories at Columbia, Mo., and Fort Worth, Tex. Silt affects environments by screening out light, changing heat radiation, blanketing stream bottoms, etc. Its relation to thermal stratification, salt content, and amount of electrolytes, its effect on mortality rate of fresh-water mussels, and the amount of organic matter carried to the bottoms of Lakes Pepin and Keokuk are discussed.

(34) Ellison, W. D.
Measuring Equipment Used in Watershed and Hydrologic Studies. Agr. Engin. 18: 107-110. March 1937.

"The watershed and hydrologic studies project of the U.S. D.A. Soil Conservation Service was established at Coshocton, Ohio, in November 1935. Since that date engineers (agricultural and hydraulic), soil scientists, foresters, geologists, and meteorologists have been studying the watersheds of this area, planning a program of research, and designing and installing equipment for scientific studies." Work at Coshocton is described.

(35) Faris, Orville A.
The Silt Load of Texas Streams. U. S. Dept. Agr. Tech. Bull. 382, 70 pp., illus. 1933.

This is a detailed study of silt deposition conducted at various points along the Brazos River and in reservoirs in Texas. A description is given of plans and methods of study, sampling equipment, method of sampling, and laboratory methods. Discusses bed silt, velocity and silt percentage curves, comparisons of discharge and silt percentage, mechanical analyses of suspended silt, determination of the silt load, and prevention of silting.
Literature cited, pages 56-57.

(36) Fiock, L. R.
Records of Silt Carried by the Rio Grande and Its Accumulation in Elephant Butte Reservoir. Amer. Geophys. Union Trans. Ann. Meeting 15: 468-473. 1934.

"Silt in the flow of the Rio Grande has been under observation, and records of the amount carried are available for a longer continuous period than for any other southwest stream... Values for the net dry weight of a cubic foot of deposited silt have been determined or assumed for use in the computations of the volume of silt carried by the Rio Grande ranging all the way from 50 to 100 pounds... Two reservoir silt-surveys have been conducted, one in 1920 and another in 1925." The results of these surveys are given, and conditions productive of a silt flow through the reservoir are discussed.

(37) Follett, W. W.
Silt in the Rio Grande. Internatl. Boundary Comm. for the Equitable Distribution of the Waters of the Rio Grande, United States and Mexico. 102 pp. 1913.

"The following compilation and discussion of the silt determinations of Rio Grande waters made prior to January 1, 1913, is for the purpose of putting into tangible and accessible shape the information which is now hidden away in filing cases and record books." In conclusion the writer says: "The fact brought out most prominently by this study is that no hard and fast rule, not even an approximate one, can be made as to what silt the river will carry in future years... It is also shown that the silt is a factor which must be seriously considered in the building of any reservoir on the Rio Grande."

(38) Forbes, R. H.
Irrigating Sediments and Their Effects upon Crops. Ariz. Agr. Expt. Sta. Bull. 53: 59-98, illus. 1906.

"The writer began an inquiry into the relations between irrigating sediments and farm crops, giving particular attention to the effects upon crops of mine tailings which, finding their way into the Gila River from concentrating plants upstream, are carried down upon irrigated lands below... The fertilizing and physical effects of sediments upon soils are discussed in this bulletin... Unusual pains have been taken to present an accurate, impartial and systematic statement of facts relating to the subject of this bulletin."

(39) Fortier, Samuel, and Blaney, Harry F.
Silt in the Colorado River and Its Relation to Irrigation. U. S. Dept. Agr. Tech. Bull. 67, 95 pp., illus. 1928.

This bulletin, dealing mainly with the silt problem in the lower Colorado River Basin in relation to irrigation, discusses the character and quantity of silt carried by the Colorado River and its larger tributaries; describes several types of silt-sampling equipment; summarizes investigations of the distribution of silt in canals and the amount carried to irrigated lands in the Imperial Valley; outlines experimental studies of silt transportation in the canal systems; and describes desilting methods used at canal intakes and gives results of experiments made to determine their efficiency.

(40) Gilbert, G. K.
Hydraulic-Mining Debris in the Sierra Nevada. U. S. Geol. Survey Prof. Paper 105: 1-154, illus. 1917.

Beginning with a historical outline of the development of hydraulic mining in the Sierra Nevada and a description of the Great Valley of California, including the effects of subsidence, this paper discusses in detail the effect of mining debris in aggravating flood conditions on basin lands and shoaling river channels and bays of the San Francisco system. Measurements were made, by comparison of maps of surveys, of the volume of debris deposited in the bays, behind a debris barrier in the Yuba River, and, from estimates based on surveys of hydraulic-mining pits and other data, of the total volume of debris moved in the basins of the Sacramento and San Joaquin Rivers. Future movements of debris in the river basins are discussed, with consideration of modification by engineering works and by execution of the plan adopted for flood control.

(41) ____
Transportation of Debris by Running Water. U. S. Geol. Survey Prof. Paper 86, 236 pp., illus. 1914.

This report is based upon detailed laboratory studies of the factors that determine the transportation capacity of streams. "The primary purpose of the investigation was to learn the laws which control the movement of bed load, and especially to determine how the quantity of load is related to the stream's slope and discharge and to the degree of comminution of the debris."

The factors studied include slope, discharge, fineness, form of channel, and velocity. Other points considered were the effect of mixtures, or debris composed of particles of many sizes, on transportation; modes of transportation, in both the movement of particles and in collective movement; the relation of load to stream energy; comparison of stream transportation with flume transportation; and the vertical distribution of velocities in a stream current.

It was found that "while the principles discovered in the laboratory are necessarily involved in the work of rivers, the laboratory formulas are not immediately available for the discussion of river problems. Being both empiric and complex, they will not bear extensive extrapolation."

(42) Glenn, L. C.
Denudation and Erosion in the Southern Appalachian Region and the Monongahela Basin. U. S. Geol. Survey Prof. Paper 72, 137 pp., illus. 1911.

"This report presents a brief summary of the results of an examination of the southern Appalachian region during the field seasons of 1904 and 1905 and of the Monongahela Basin in West Virginia and Pennsylvania in 1907, made for the purpose of studying the effect of deforestation and consequent erosion of the steep mountain slopes on geologic, hydrologic, and economic conditions, both in the mountain region itself and in the surrounding areas through which the many streams that rise in the high Appalachians flow on their way to the Mississippi, the Gulf, or the Atlantic."
Briefly describes sedimentation conditions, particularly sanding of channels and flood plains and silting of power reservoirs, along the principal streams in the regions studied.

(43) Griffith, W. M.
Theory of Silt and Scour. Engineering (London) 123: 72. January 21, 1937.

In discussing R. G. Kennedy's general law the author points out that the power of a stream to transport silt in suspension is derived from vertical eddies. Outlining his formula he says: "The application of this theory is made to the design of bridge-foundations and finally to river-training works. The theory is also advanced that there is a particular width of river which will give the minimum of shoaling or scour action under varying flood-volumes."

(44) ____
A Theory of Silt Transportation. Amer. Soc. Civ. Engin. Proc. 64: 859-874, illus. May 1938.

"A theory of silt transportation is outlined in this paper, and equilibrium equations are presented which it is claimed are applicable to channels of all sizes and shapes, provided the silt load and the bed consist of 'loose granular material', and provided certain hydraulic conditions are satisfied. The equations are of special value in problems relating to river-control works and tidal river outfalls; for example, they can be used to estimate the change in bed level that will result from widening or 'tightening' a river section, or to determine whether a proposed dredge cut can be expected to maintain itself." --Synopsis.

(45) Grover, N. C.
The Recording of River Discharge. Military Engin. 20: 120-124. 1928.

Discusses importance of river-discharge records and types of gages used in recording. In large rivers such as the Colorado, where heavy silt loads and shifting bed are combined with depths as great as 50 feet and velocities as great as 15 feet per second, changes in design of meters were necessary to prevent rapid wearing of bearings, and to make possible soundings in deep swift water.
Describes the mechanics of stream gaging and uses for discharge data.

(46) ____
Stream Flow: Suspended and Dissolved Matter in Streams on and near Soil Conservation Project, Temple, Texas. U. S. Geol. Survey, pp. 1-27. March 1936. (Mimeographed.)

A report on measurements of stream flow and of suspended and dissolved matter in streams in and near the Temple project. Includes tables showing daily discharge, distribution of loads of suspended matter, and daily loads of suspended matter at three stations. The tables indicate that a large proportion of the total yearly load of suspended matter is carried during comparatively short periods of time. A table of analyses of dissolved matter is included.

(47) ____
United States Geological Survey Records of Suspended and Dissolved Matter in Surface-Waters. Amer. Geophys. Union Trans. pt. 2, Ann. Meeting 17: 444-446. 1936.

Reviews the work of the Geological Survey in measuring discharge and suspended matter in American rivers since 1902, and tells why the survey was allotted funds in January 1934, primarily for the establishment and operation of stream-flow-measurement stations and for obtaining records of movement of suspended matter at eight erosion-control projects.

(48) Grover, N. C., and Howard, C. S.
The Passage of Turbid Water through Lake Mead. Amer. Soc. Civ. Engin. Proc. 63 (pt. 1): 643-655, illus. April 1937.

A record and description of silt flow from Lake Mead above Boulder Dam from March 1 to October 31, 1935. "Turbid water carrying a considerable load of fine silt was discharged from Lake Mead, above Boulder Dam, in Arizona and Nevada, at three different periods during 1935 when the reservoir was 70 to 90 miles long and contained from 4,000,000 to 5,000,000 acre-feet of water. Apparently, it flowed through the reservoir essentially unmixed. Chemical analyses of the water entering into, and discharged from, the reservoir corroborate the conclusions drawn from the observations of silt as to the occasional discharge of essentially unmixed water. The phenomenon is ascribed to the greater specific gravity of the incoming water relative to the generally clear water at the surface of the lake, due probably, in part, to its silt load. A practical significance is suggested with respect to the possibility of increasing the passage of fine silt through a reservoir, thereby prolonging its effective life. References are made to other known occurrences of similar phenomena."

(49) Grunsky, C. E.
Silt Transportation by Sacramento and Colorado Rivers and by the Imperial Canal. Amer. Soc. Civ. Engin. Trans. 94: 1104-1151 (with discussions). 1930.

This paper presents data relating to the transportation of detrital material by the Sacramento and Colorado Rivers and by the Imperial Canal, with results of personal observations.
Estimates have been made of the volume of silt transported by the canal, on the basis of repeated surveys and the volumes of silt removed from the head reaches.
Suspended load of the Colorado has been determined with unusual care at Yuma, Ariz.; the resulting data have thrown much light on distribution and transportation of silt.

(50) ———
Some Aspects of the Flood-Control Problem. Military Engin. 24: 336-343. 1932.

Discusses the formation of alluvial valleys, the overtopping of river banks during floods, the formation of flood basins, the effect of confining a river in its channel on flood discharge, the formation of deltas at river mouths; discusses the character of the river bed in relation to the

(50) Continued.
distance upstream, the effect of river shortening on water level, sediment load, and readjustment of bed, the effect of temporary storage on the shape of the flood wave and the maximum stream flow, and gives an analysis of formulas for computing the maximum rainfall and maximum stream flow.

(51) Happ, S. C.
Fertile Valleys Laid Waste by Upland Erosion. Soil Conserv. 2: 194-198, illus. March 1937.

A discussion of the problem of sedimentation damage to valley lands and other downstream resources resulting from excessive upland erosion, with particular reference to the Wells drainage district in Lafayette County, Miss. Discusses the various types of damage and their causes. The need for consideration of upland erosion, the fundamental cause of damage, in any attempts to protect or improve valley lands is emphasized.

(52) Harper, H. J., and Murphy, H. F.
A Study of the Amount of Sediment Carried by Runoff Water. Okla. Acad. Sci. Proc. 10: 114-117. 1930.

Article on results of study to determine the amount of sediment carried in run-off water in several streams at flood stage, from terraced and unterraced soils in Oklahoma. Streams studied include Stillwater, Black Bear, and Cow Creeks, and the Cimarron River. Comparisons made with suspended loads of the Colorado River, Rio Grande, North Fork of Red River, and Salt Fork of Red River.

(53) Hemphill, R. G.
Silting and Life of Southwestern Reservoirs. Amer. Soc. Civ. Engin. Trans. 95: 1060-1073. 1931.

This paper refers to the silt load of several of the principal streams of the Southwest to indicate the importance of the silt problem in that region and the necessity for a comprehensive study of it to meet adequately water-storage problems of the future.

(54) Hill, R. A.
Silting of Reservoirs Formed by Large Dams: Its Measurement and Prevention. Second Congress on Large Dams Trans. 5: 203-206. (Washington, D. C., 1936.) 1938.

Discusses the possible effects of erosion control on available water supplies and silting of reservoirs, particularly the extent to which the rate of accumulation would be altered by feasible methods of erosion control, and the amount by which the available water supply might be reduced by increased transpiration and evaporation. Outlines the usual procedure for estimating silting rates of prospective reservoirs, and suggests that the safest index is the relation between the rate of accumulation indicated by suspended-load samples and that found by experience on similar streams. Discusses the problem and methods of computing the amount of silt deposited, comparing the accuracy of contours and transverse sections. Attempts to prove that in the case of Elephant Butte Reservoir erosion control to reduce silting would be economically impracticable.
Concludes that prevention of silting will rarely be found practicable, that removal of silt is too costly in most cases, and that enlargement of reservoirs or construction of new ones will generally be most economical.

(55) Howard, C. S.
Suspended Matter in the Colorado River in 1925-1928. U. S. Geol. Survey Water-Supply Paper 636: 15-44, illus. 1930.

Summarizes previous and recent investigations, including methods of sampling; discusses methods of determining the quantity of suspended matter, variation in quantity in different parts of the cross section, variation from day to day and during the period studied, and variation with discharge; gives computations of annual loads of suspended material based on present and previous investigations; briefly discusses bed load, showing that a considerable but unknown amount of material is moved along the bottom; discusses the volume that the suspended material will occupy in a reservoir. Includes extensive tables giving the quantities of suspended matter in samples taken during 1926, 1927, and 1928 from the Colorado River at Bright Angel Creek, near Grand Canyon, Ariz.

(56) Howard, C. S.
Suspended Matter in the Colorado River, 1925-1935. Amer. Geophys. Union Trans. pt. 2, Ann. Meeting 17: 446-447. 1936.

Discusses the quantity and nature of suspended matter in various parts of the Colorado River and certain of its more turbid tributaries, with special reference to variation with time and place. Annual loads of suspended matter and annual discharge at the Grand Canyon gaging station for the period 1925-1935 are shown and compared diagrammatically.

(57) Humphreys, A. A., and Abbott, H. L.
Report upon the Physics and Hydraulics of the Mississippi River. Corps of Topog. Engineers, U. S. Army Prof. Papers, No. 4, Phila., 1861; reprint with additions, Prof. Papers, No. 13: 1-691. Wash. 1876.

Describes in detail the Mississippi, its drainage basin and principal tributaries; discusses the science and laws of hydraulics as applied to rivers; includes cross-section, current, and discharge measurements; describes the delta and mouths of the Mississippi and plans for improvement. Includes estimates of the total sediment discharge, including bed load, suspended load, and deposits in alluvial swamps; discusses comparable data on European rivers and the Ganges.

(58) Kenyon, E. C.
Discussion of "Measurement of Debris Transported from Burned Areas" by C. W. Sopp. Report on Progress Conference on Water Conservation, Los Angeles, Calif., March 13-14, 1935. Amer. Soc. Civ. Engin., December 1935, pp. 68-73.

Describes the various stages of debris transportation from a newly burned area. Includes a table giving mechanical composition, apparent percentage volume of wet solids after 24-hour settlement, and weight relation of dry to wet solids of samples taken during rising and falling stages of stream flow from burned areas in Haines and Dunsmuir Canyons in December 1934.

(59) Lane, E. W.
Stable Channels in Erodible Material. Amer. Soc. Civ. Engin. Trans. 102 (paper 1957): 123-142, illus. 1937.

"The design of the All-American Canal, which will divert 15,000 cu ft per sec from the Colorado River, required a thorough study of stable channel shapes. Data from various sources were conflicting and unsuitable for the unusual conditions on this canal. These data were analyzed and conclusions drawn regarding the various factors controlling stable channel shapes and the relation between them." A general discussion followed the reading of this paper.

(60) Lawson, L. M.
Effect of Rio Grande Storage on River Erosion and Deposition. (Discussion by Herman Stabler and reply by author. Engin. News-Rec. 95: 968-969. December 10, 1925.)

Describes the principal features of the irrigation project served by Elephant Butte Reservoir, and contrasts flood conditions and erosion and deposition in the project area before and after construction of Elephant Butte Dam and the four diversion dams below. Concludes that the general effect of Elephant Butte Reservoir has been to prevent large destructive floods and to greatly reduce the amount of sediment carried by the lower river; also concludes that aggradation of the lower river channel is due to inadequate slope and decrease of flow, and that "no great degradation of the river channel is found in the upper reaches of the river and such a tendency is retarded by the existence of diversion dams and canyon sections."

In his discussion Stabler analyzes data on cross-section areas given by Lawson, maintaining that they indicate a decided degradation for 100 miles below Elephant Butte.

(61) ———
Sand Sluicing on the Rio Grande Project. Reclam. Era 16: 74-75, illus. 1925.

Compares modes of transportation of sand and silt in the Rio Grande; describes sluicing and skimming arrangements at various diversions of the Rio Grande project with notes on their effectiveness; discusses types and effectiveness of various arrangements for removing sand from canals. The measures so far adopted in maintaining capacities of canals have been reasonably successful, but at the expense of adding to the amount of deposition in the river itself in the lower end of the project, where the river channel is now

(61) Continued.
in places higher than the surrounding farm land. Complete solution lies in a rectified river channel, in which elimination of meanders and construction of protected embankments to confine the limited flow will tend to restore the former scouring action of the larger floods.

(62) Leighly, John.
Turbulence and the Transportation of Rock Debris by Streams. Geogr. Rev. 24: 453-464, illus. July 1934.

Stresses turbulence as the cause of suspension of debris in water. Shows that the ability of a stream to erode its bed is not a direct function of velocity, but that both factors are functions of other independent variables, such as gradient and form and area of cross section. Discusses the distribution of turbulence in stream cross sections, the relation between turbulence and turbidity, and the diffusion of suspended matter as a phase of transportation. The writer concludes that "all stream deposits are formed in areas that are lateral to some thread of maximum velocity and its flanking threads of maximum turbulence."

(63) Love, S. K.
Suspended Matter in Several Small Streams. Amer. Geophys. Union Trans. pt. 2, Ann. Meeting 17: 447-452. 1936.

Gives data on discharge and suspended matter for the 15-month period ended June 30, 1935, for streams in Kansas, Missouri, North Carolina, Oklahoma, South Carolina, Texas, Washington, and Wisconsin. The measurements are from 34 gaging stations located on eight regional projects of the Soil Conservation Service.

(64) Marple, Albert.
Making a Stream Build Its Own Check Dams. Engin. News-Rec. 81: 368-369, illus. 1918.

Describes a scheme for building up check dams to prevent bank erosion by constructing porous check dams which will catch and be made impervious by sediment and floating debris. It is claimed that once the basins back of the dams begin to fill it is impossible for the stream bed to shift. A series of such dams may be used to control the entire length of a stream or only points where protection is necessary. Illustration of a partially built system on Laurel Canyon Creek, Calif., giving specification costs, materials, and heights.

(65) National Research Council.
Reports of the Committee on Sedimentation, 1924, 1925-1926, 1926-1927, 1927-1928, 1928-1929, 1929-1930, 1930-1932, 1932-1934, 1935-1936, 1936-1937, and 1937-1938, on Researches in Sedimentation.

The report for 1924 contains the following papers: Studies in Sedimentation in Canadian Colleges and Universities, by E. M. Kindle; Sedimentary Studies in Eastern Colleges and Universities of America, by J. V. Lewis; Studies in Sedimentation in Colleges and Universities of the Central States, by A. C. Trowbridge; Studies in Sedimentation in Western Colleges and Universities, by Eliot Blackwelder; Sedimentary Studies by the State Geological Surveys of the United States, by J. A. Udden; Studies of Sediments by the Oil Companies, by L. M. Neumann; Studies of Sediments in European Laboratories, by W. A. Tarr; Progress of Studies on Seasonal Deposition of Sediments, by R. W. Sayles; Nature of Soil Components and Their Relations to Sedimentation, by R. O. E. Davis; Chemical Work Relative to Sedimentation, by George Steiger; Some Recent Investigations by Physicists That Have a Bearing on Problems in Sedimentation, by C. E. Van Orstrand; Note on the Representation of the Distribution of Grains in Sands, by C. E. Van Orstrand; Suggestions for Future Studies of Sediments and in Sedimentation, by The Committee; Subaqueous Formation of Mud Cracks, Artificial Formation of Oolites, and The Treatise on Sedimentation, by W. H. Twenhofel.

The report for 1925-1926 contains the following papers: Introductory Statement, by W. H. Twenhofel; Sedimentation Studies in Eastern Colleges and Universities, by C. A. Bonine; Sedimentation Studies in Mississippi Valley Colleges and Universities, by A. C. Tester; Sedimentation Studies in the Colleges and Universities of the Western Mountain States, by Eliot Blackwelder; Sedimentation Studies in the Colleges and Universities of Canada, by R. C. Wallace; Sedimentation Studies in Europe, by L. W. Collet; Sedimentation Studies by Oil Companies, by L. M. Neumann; Sedimentation Studies Recently Made, or in Progress, in Washington, D. C., by Kirk Bryan; Chemical Studies Which Bear on Sedimentation, by George Steiger; Some Recent Investigations by Physicists That Have a Bearing on the Problems of Sedimentation, by C. E. Van Orstrand; Work Done in the Ground Water Division of the Geological Survey That Relates to the Problems of Sedimentation, by O. E. Meinzer; The Colloidal Material of Soil, and Bibliography of Some of the More Recent Soil Articles Related to Sedimentation, by R. O. E. Davis; Recent Studies of North American Lakes Yielding Data Bearing on Sedimentary Problems, by E. M. Kindle; Modern Marine

(65) Continued.

Sediments and Sedimentary Processes, by T. W. Vaughan; Brief Review of Studies in Glacial Sedimentation Previous to 1925, and Studies of Glacial Sediments in 1925, by M. M. Leighton; Varved Sediments, by Ernst Antevs; Studies on the Petrography of Sediments, by W. H. Twenhofel; Silting of Reservoirs, Statements by Engineers with Bibliography, by Kirk Bryan; A Proposed Scale of Hardness and Cohesion for Rocks, by E. M. Kindle; Papers on Concretions and Chert and Flint, by W. A. Tarr.

The report for 1926-1927 contains the following papers: Introduction, by W. H. Twenhofel; Report of Subcommittee on a Scale of Hardness for Soft Rocks, by E. M. Kindle (chairman), Charles Terzaghi, and R. C. Wallace, with References on Tests of Hardness, Cohesion, and Consistency, by Kirk Bryan; Report on Work Done in Europe in the Study of Sediments, by L. W. Collett; Studies in Sedimentation by the State Geological Surveys of the United States, by W. A. Nelson; Chemical Studies Which Bear on Sedimentation, by George Steiger; Work on Soils Related to Sedimentation at the United States Bureau of Soils, by R. O. E. Davis; Work in Ground Water Hydrology That Relates to Problems of Sedimentation, by O. E. Meinzer; Limnological Investigations in Wisconsin in Relation to Lake Deposits, by Chancey Juday; Studies of Glacial Sediments in 1926, by M. M. Leighton; Studies of Varved Sediments, by Ernst Antevs; Investigations of Modern Marine Sediments, compiled by T. W. Vaughan; Recent Work on Dolomitization, by R. C. Wallace; Formation of Marine Shell Beds, by Ernst Antevs; Recent Progress in the Study of Certain Desert Deposits of the Great Basin Region, by Eliot Blackwelder; Studies of Chert, Flint, and Concretions, by W. A. Tarr; Heavy Mineral Investigations in California, by R. D. Reed.

The report for 1927-1928 (Natl. Research Council Reprint and Cir. Ser. 85.) contains the following papers: Introduction, by W. H. Twenhofel; Report of Research on Sedimentary Rocks by British Petrologists, by H. B. Milner; Recent Work on Bentonite, by C. A. Bonine; Varved Sediments, by Ernst Antevs; Chemical Studies Which Bear on Sedimentation, by George Steiger; Studies on Coarse Sediments, 1923-1927, by C. K. Wentworth; Recent Progress in the Study of the Salina Formation, by D. H. Newland; Studies of Glacial Sediments in 1927, by M. M. Leighton; A Summary of the Activities of Bacterial Agencies in Sedimentation, by G. A. Thiel; Notes on Sedimentary Deposits in the Desert, by Eliot Blackwelder; Studies of Soils Which Bear on Sedimentation, by H. H. Bennett.

The report for 1928-1929 contains the following papers: Introduction, by W. H. Twenhofel; The Intertidal Zone of the

(65) Continued.

Wash, England, by E. M. Kindle; Research on Sediments by British Geologists for the Year 1928, by H. B. Milner; Bibliography of Research on Sediments by European Geologists in 1927 and in Part in 1928, by Edouard Parejas; Silt Studies on American Rivers, by Kirk Bryan; Studies on Marine Bottom Deposits at the Scripps Institution of Oceanography, by T. W. Vaughan; Research in Marine Bacteriology, by A. H. Gee; Calcium Carbonate in Sea Water, by A. H. Gee and E. G. Moberg; Research on Marine Sediments Conducted by the American Petroleum Institute, by P. D. Trask; Studies on Sedimentation at the Jaques Loeb Laboratory, Stanford University, by L. B. Bocking; Recent Publications on Chert, Flint, Concretions, Cone-in-Cone and Stylolites, by W. A. Tarr; Varved Sediments, by Ernst Antevs; Sedimentational Research on the Pacific Coast, by R. D. Reed; Micropaleontology in the Mid-Continent Region, by Dollie Radler; Heavy Mineral Work in the Mid-Continent Region, by Fannie Carter Edson; Lake Deposits in the Basin and Range Province, by E. Blackwelder; Bibliography on Chemical Studies Which Bear on Sedimentation, by George Steiger; Studies of Glacial Sediments in 1928, by M. M. Leighton; Investigations of Fluvial Deposits, by A. C. Trowbridge.

The report for 1929-1930 (Natl. Research Council Reprint and Cir. Ser. 98, 1931.) contains the following papers: Introduction, by W. H. Twenhofel; Sedimentational Research on the Pacific Coast, 1930, by R. D. Reed; Investigations of Marine Sediments at the Scripps Institution of Oceanography, by T. W. Vaughan; Descriptions of Deep-Sea Bottom Samples from the Western North Atlantic and Caribbean Sea (Abstract), by E. M. Thorp; Analytic Methods Required for the Study of Carbonate Equilibrium, by E. G. Moberg; Calcium Carbonate Relations in the Sea-Water at Tortugas, Florida, by Haldane Gee; Research on Sediments by British Scientists during 1929-1930, by H. B. Milner; Bibliography of Research on Sediments by Western Continental European Geologists in 1928 and 1929, by Edouard Parejas; Silt Studies in 1928 and 1929, by Kirk Bryan; Wind-Worn Stones or Ventifacts--a Discussion and Bibliography, by Kirk Bryan; Varved Sediments, by Ernst Antevs; Notes on Recent Publications on Phosphates, by G. R. Mansfield; Recent Studies on the Influence of Biochemical Agencies in Sedimentation, by G. A. Thiel; Studies of Coarse Sediments, 1928-1929, by C. K. Wentworth; Recent Publications on Bentonite, by C. A. Bonine; Chemical Studies Bearing on Sediments, by George Steiger; Studies in Glacial Sediments in 1929, by M. M. Leighton.

The report for 1930-1932 contains the following papers: Introduction, by W. H. Twenhofel: The Classification and Terminology of the Pyroclastic Rocks, by C. K. Wentworth and

(65) Continued.

Howel Williams; Recent Advances in the Study of Peat, by W. E. Powers; Studies of Recent Marine Sediments Conducted by the American Petroleum Institute, by Parker D. Trask; Experiments with the Settling of Bentonite in Water, by E. M. Kindle; The Relation of the Buffer Mechanism of Sea Water to the Solubility of Calcium Carbonate, by D. M. Greenberg and E. G. Moberg; Notes on Investigations of Modern Marine Sediments in California, by T. W. Vaughan; Bacterial and Chemical Factors in Lime Deposition at Tortugas, Florida, by Holdane Gee; Report on Some Work on Sediments Done in Germany in 1931, by Hans Becker; Varved Sediments, by Ernst Antevs; Chert and Flint, Concretions, and Cone-in-Cone, by W. A. Tarr; Sedimentation Studies at Stanford University, by Eliot Blackwelder; Study of the Abrasional Work of River Ice and of Glaciers, by C. K. Wentworth; Chemical Papers on Sedimentation, by George Steiger; Some Recent Applications of Physics to Sedimentation Problems, by C. E. Van Orstrand; Investigations in Ground Water Hydrology That Bear on Sedimentation, by A. M. Piper; Research on Sediments by British Scientists during 1930-1932, by H. B. Milner; Recent Studies with Reference to the Role of Microorganisms in Sediment, by G. A. Thiel; Accessory Minerals of Crystalline Rocks, by A. N. Winchell, E. S. Larsen, J. C. Reed, J. T. Stark, A. C. Tester, and J. F. Wright; Abstracts of Literature on Accessory Minerals of Igneous Rocks, by J. C. Reed; Abstracts of Literature on Accessory Minerals in Sedimentary Rocks as Related to Possible Source Crystalline Rocks, by A. C. Tester; Studies in Glacial Sediments 1930 and 1931, by M. M. Leighton and E. Townley.

The report for 1932-1934 contains the following papers: Introduction, by A. C. Trowbridge; Recent European Studies on Sedimentation; Varved Sediments, by Ernst Antevs; German Contributions to the Work on Sediments, 1930-33, by Hans Becker; Sedimentation Studies at Stanford University, 1932-1934, by Eliot Blackwelder; Studies in Glacial Sediments, 1932-1933, by M. M. Leighton and Enid Townley; Research on Sediments by British Scientists during 1932-1934, by Henry B. Milner; The Mineralogy of the Sedimentary Rocks, by F. J. Pettijohn; Hydrologic and Hydrographic Investigations That Bear on Sedimentation, 1932-1933, by Arthur M. Piper; Chemical Papers Bearing on Sedimentation, by George Steiger; Current Bibliography of Recent Sediments and Source Beds of Petroleum, by P. D. Trask; Notes on Various Types of Sediments, by W. H. Twenhofel; Studies of Marine Bottom Deposits at the Scripps Institution of Oceanography, by T. Wayland Vaughan; Some Preliminary Observations on Oxidation-Reduction Conditions in Marine Bottom Deposits in the Gulf of Catalina, by C. E. Zo Bell; The Terminology of Coarse Sediments, by Chester K. Wentworth.

(65) Continued.

The report for 1935-1936 contains the following papers: Report of the Chairman, by P. D. Trask; Notes on 1934-35, Articles on Siliceous Sediments, by W. A. Tarr; Terminology of Medium-Grained Sediments, by V. T. Allen (with Notes by P. G. H. Boswell).

The report for 1936-1937 contains the following papers: Report of the Chairman, by P. D. Trask; Sedimentation Studies by the Soil Conservation Service, by C. B. Brown; Research on Sediments by British Scientists during 1934-1936, by H. B. Milner; Mineralogy of Sedimentary Rocks, 1934-1936, by F. J. Pettijohn; Nomogram for the Settling Velocity of Spheres, by Hunter Rouse; Bibliography on Roundness and Shape of Sedimentary Particles, by R. D. Russell and R. E. Taylor; Terminology of the Fine-Grained Mechanical Sediments, by W. H. Twenhofel; The Bottom Sediments of Lake Monona, a Fresh-Water Lake of Southern Wisconsin, by W. H. Twenhofel; A Hydraulic Coring Instrument for Submarine Geologic Investigations, by F. M. Varney and L. E. Redwine; Classification and Selected Bibliography of the Surface Texture of Sedimentary Fragments, by Lou Williams.

The report for 1937-1938 contains the following papers: Report of the Chairman, by P. D. Trask, Terminology of the Chemical Siliceous Sediments, by W. A. Tarr; German and Austrian Papers on Mechanical Analysis, by H. C. Stetson; Papers Dealing with Sediments and Sedimentation since 1933, by H. C. Stetson; Bibliography Relating to Organic Content of Sediments, by P. D. Trask; Unpublished Theses on Sedimentation in American Colleges and Universities, by P. D. Trask; Sedimentation Studies by the Soil Conservation Service, by C. B. Brown.

(66) O'Brien, M. P.

Notes on the Transportation of Silt by Streams. Amer. Geophys. Union Trans. Ann. Meeting 17 (pt. 2): 431-436. 1936.

"Several recent papers on the transportation of bed-load and suspended material by flowing water have included assumptions or theories which are in disagreement either with fundamental mechanical principles or with experimental results. Since a number of experimental programs are in progress, a discussion of these problems may be of some value in the interpretation of results." Discusses Gilbert's theory of silt transportation, and the theory of turbulent flow as developed by Von Karman, Prandtl, and G. I. Taylor.

(67) O'Brien, M. P.
Review of the Theory of Turbulent Flow and Its Relation to Sediment-Transportation. Amer. Geophys. Union Trans. Ann. Rept. 14: 487-491. 1933.

"In flowing streams the percentage of suspended material decreases with distance above the bed and, with a certain depth and average velocity, particles above a critical size or specific gravity are not put into suspension. As the random velocities which make up the turbulent flow (turbulent flow as distinguished from laminar or viscous flow) also provide the means for carrying the particles into the interior of the fluid, a quantitative theory of turbulent flow should also provide a theory for distribution of material in suspension. The present paper is a review of the theory of turbulent flow developed by Osborne Reynolds, Prandtl, von Karman, and Taylor, and of its application to the distribution of suspended material by Schmidt and others."

(68) ____ and Rindlaub, B. D.
The Transportation of Bedload by Streams. Amer. Geophys. Union Trans. 15 (pt. 2): 593-603, illus. 1934.

"The present paper is the result of a critical survey of available data made to ascertain whether or not a quantitative prediction of bed-movement is now possible."

(69) Pierce, R. C.
Measurement of Silt-Laden Streams. U. S. Geol. Survey Water-Supply Paper 400-C: 39-51, illus. 1916.

"Hydraulic engineers who may have occasion to measure streams carrying heavy loads of silt will doubtless be interested in the following account of the special difficulties encountered and the results obtained in measuring the flow of San Juan River." Silt in the San Juan and movement of debris are discussed in detail. "The results of discharge measurements made at the San Juan gaging station, together with a diagram showing the rating curve, area curve, and velocity curve, are presented herewith, as well as estimates for the four months (May to August, 1915) that the writer was engaged on the work."

(70) Ramser, C. E.
Erosion and Silting of Dredged Drainage Ditches. U. S. Dept. Agr. Tech. Bull. 184, 55 pp., illus. 1930.

"The results of observation and cross-sectional and hydraulic measurements made between 1913 and 1921 on 22 dredged drainage ditches in Mississippi, Tennessee, and Iowa are reported... Data are also presented on conditions affecting erosion and silting in a channel, and a practical application of the results is described." --Expt. Sta. Rec. 63: 580. 1930.

(71) Reed, Oren.
Swiss Methods of Avoiding Silt Deposits in Reservoirs. Engin. News-Rec. 107: 289-290, illus. August 21, 1931.

Refers to the general problem of damage to reservoirs by silting, and describes the methods used to prevent silting of two Swiss reservoirs. At one of these, debris-laden floods are bypassed through a tunnel; at the other, excessive silting was avoided by locating the dam at a point where the flow and silt load of the inflowing stream were low but where the flow could be increased by diverting desilted water from another stream through a tunnel.

(72) Renner, F. G.
Conditions Influencing Erosion on the Boise River Watershed. U. S. Dept. Agr. Tech. Bull. 528, 32 pp., illus. 1936.

The relative importance of each factor influencing present erosion conditions is the basis of the author's study. "The survey has brought to light the seriousness of erosion on a valuable watershed and a knowledge of the factors which, under the conditions peculiar to the watershed, have been chiefly responsible for the erosion... The results point to the immediate necessity of restoring the plant cover to a density of at least 30 percent, reducing the excessive rodent population, and initiating improvements in range and livestock management which will relieve conditions on areas particularly susceptible to erosion." See also Science 84: 62-63, July 17, 1936.

(73) Richardson, E. G.
Transport of Silt by a Stream. Phil. Mag. 17: 769-783. April 1934.

"It has been found that the transport of silt is in the main due to turbulence in the stream, under which conditions the vertical distribution is nearly exponential, and the lifting force... is proportional to the square of the velocity. Below the critical speed the silt is moved to a much less extent, and the movement is confined to the smaller particles in the lower strata of the stream." The writer summarizes these investigations in conclusion.

(74) Robinson. H. F.
Silt Problem of Zuni Reservoir. Amer. Soc. Civ. Engin. Trans. 83: 868-893, illus. (Includes discussions by Elwood Mead, C. S. Jarvis, G. M. Post, and the author.) 1920.

Discusses the silting of reservoirs in the arid part of the United States, with special reference to Zuni Reservoir in New Mexico. Gives estimates of the probable life of the reservoir, and discusses experiments on silt compaction by Rollin Ritter, the relation of silt load to the magnitude of floods, and remedial measures to reduce silting of Zuni Reservoir.

(75) Rothery, S. L.
A Problem of Soil in Transportation in the Colorado River. Amer. Soc. Civ. Engin. Trans. 99: 524-543, illus. 1934. (Discussion by C. E. Grunsky and others, pp. 544-575.)

"This paper is concerned principally with the problem of excluding soil, transported by the Colorado River, from the Canal System of Imperial Valley, in California. Its purpose is: (a) to feature the relative importance of the bed load of the Colorado River and to provide some conception of the extent of the unknown volumes of soil transported; (b) to present the extent of the unknown and anticipated future river-flow conditions pertinent to soil conveyance; and (c) to propose fundamental requirements for a diversion structure that will exclude all the bed load and a part of the suspended load, thus permitting minimum sizes for--or, perhaps, eliminating as unnecessary--the enormous settling basins which are expected to desilt the large diverted flow, and also permitting lessened sluicing operations for the disposal of the sludge."

(76) Saveson, I. L., and Overholt, Virgil.
Stream Bank Protection. Agr. Engin. 18: 489-491, illus. 1937.

After a general discussion of stream-bank erosion, describes a combined field and laboratory study of control by means of deflectors of various types, heights, and lengths placed in various positions, supplemented by vegetation, particularly white and black willow, planted along the eroding stream banks. Conclusions based on model tests and field observations are discussed in detail.

(77) Saville, Thorndike.
Water-Power Investigation of Deep River, N. C. Geol. and Econ. Survey Econ. Paper 54: 1-43, illus. 1924.

A complete study of developed and potential power, including discussion of fall, stream flow, silting conditions in existing power ponds, and possible methods of silt removal.

(78) Schuyler, J. D.
Reservoirs for Irrigation, Water-Power, and Domestic Water-Supply. 414 pp., illus. New York, John Wiley and Sons. 1901.

"An account of various types of dams and the methods and plans of their construction, together with a discussion of the available water supply for irrigation in various sections of arid America; the distribution, application, and use of water; the rainfall and run-off, the evaporation from reservoirs; the effect of silt upon reservoirs, etc."--From title page.

(79) Sonderegger, A. L.
Modifying the Physiographical Balance by Conservation Measures. Amer. Soc. Civ. Engin. Trans. 100: 284-346. 1935. (With discussion by H. H. Chapman, E. B. Debler, Frank E. Bonner, C. S. Jarvis, W. P. Rowe, J. C. Stevens, G. H. Matthes, J. B. Lippincott, R. E. Rule, and A. L. Sonderegger.)

Illustrates the theory of a physiographical balance produced by precipitation, erosion, and debris transportation and deposition by streams, by showing the effect on such a balance of (1) changes in the watershed cover, (2) effect of

(79) Continued.
regulation on the natural balance of a stream system, and (3) effect of debris barriers on the stability of the stream bed on the debris cone. Bonner, in his discussion, gives the average rate of silt production in the United States as equal to 1 inch in 400 years.

(80) Stabler, Herman.
Silt in the Proposed Reservoirs of the Ohio Basin. Engin. News 60: 649-651. December 1908.

Presents estimated rates of sediment accumulation in reservoirs in various parts of the Ohio drainage basin, based on average annual run-off and concentration of suspended matter. Results indicate that reduction of 10 percent in capacity of reservoirs will occur in periods ranging from 500 to 2,410 years and averaging 835 years for the entire basin. These figures believed to be accurate within 10 to 15 percent. The controlling factor is shown to be the relation of reservoir capacity to drainage area.

(81) ———
Some Stream Waters of the Western United States, with Chapters on Sediment Carried by the Rio Grande and the Industrial Application of Water Analyses. U. S. Geol. Survey Water-Supply Paper 274, 188 pp. 1911.

"A systematic study of the waters likely to be utilized on the Reclamation Service projects was made in order to determine the influence of the salinity of the waters on the growth of vegetation and the effect of suspended matter in silting canals and reservoirs." The work was begun early in 1905 and continued during 1906. Samples were collected for an extended period at 55 stations. "The point of collection was selected with a view to obtaining a fair average sample of the water flowing in the stream, and occasionally samples were taken from different parts of the cross section in order to determine any possible local variation in quality of waters." Results at sampling stations are given in full, and the methods of analysis and accuracy of work and tables considered.

(82) Stabler, Herman, and Parker, H. N.
The Silt Problem; Kaw River. Engin. News 63: 643-644. June 2, 1910.

This paper summarizes a silt-deposition study covering 72 periods of approximately 10 days each from 1900 to 1908. An analysis of the study is presented in tabular form.

(83) Stevens, J. C.
The Silt Problem. Amer. Soc. Civ. Engin. Proc. 60: 1179-1218, illus., October 1934; 62 (8, pt. 2): 207-288. October 1936. (With discussion by H. G. Nickle, E. W. Lane, F. E. Bonner, M. P. O'Brien, H. F. Blaney, W. W. Waggoner, P. R. R. Bisschop, Herman Stabler, N. C. Grover, and J. C. Stevens.)

"All the basic data that the writer could secure on the silting of reservoirs, where actual capacity surveys have been made to determine the extent of silting, are contained in this paper. Remedial measures for silt elimination are presented and discussed. A table contains a brief of all data on the silt transported by the streams of the world. The physical laws of silt transportation are outlined with pertinent discussion. The control of silt in canals, reservoirs, and on watersheds is then considered. The paper closes with data and discussion on the origin of silt."

(84) Straub, L. G.
Transportation of Sediment in Suspension. Some Practical Conclusions from Field and Laboratory Investigations. Civ. Engin. 6: 321-323. May 1936.

Outlines some of the findings concerning the principles underlying transportation of sediment in suspension, as follows: The manner in which particles of various diameters distribute themselves in vertical section; the effect of certain changes in the chemical composition of the water on the mechanical composition of suspended load; and the relation between the stream discharge and the quantity of sediment in suspension. Also discusses the selection of a model law to insure similarity in laboratory studies of sedimentation basins.

(85) Sykes, Godfrey.
The Colorado Delta. Carnegie Inst. Wash. Pub. 460, 193 pp., illus. (Washington, D. C.) 1937.

Divided into three parts: History of Exploration and Navigation; Physiographic History; and Stream Dynamics. Headings of Part III are: The Detrital Load of the Colorado River Water; Fluctuation and Rhythm in the Movement of Debris; Deposition of the Detrital Material.
Bibliography, pages 177-188.

(86) Taylor, T. U.
Silting of the Lake at Austin, Texas. Tex. Univ. Bull. 2439, 23 pp., illus. October 15, 1924.

"The silting-up of reservoirs, for purposes of comparison, is best reduced to heights or depths on a square-mile base. The results will not be true for any reservoir in which there is an appreciable current acting on the bottom of basin; i.e., on the upper surface of the silt. In the old lake at Austin the lake level could sink to ten feet below the crest of the dam, and still have a fair current in the penstocks, as the bottom of the forebay was 12 feet below the crest of the dam." Historic floods on the Colorado and Brazos Rivers are discussed.

(87) ____
Silting of the Lake at Austin, Texas. Amer. Soc. Civ. Engin. Trans. 93: 1681-1735, illus. 1929. (With discussion by L. M. Lawson, C. H. Eiffert, Oren Reed, Charles Schultz, J. B. Hawley, H. F. Robinson, Julian Montgomery, Kirk Bryan, J. C. Stevens, P. A. Welty, Banks McLaurin, R. G. Tyler, E. C. H. Bantel, R. F. Walter, W. J. Powell, R. I. Meeker, and T. U. Taylor.)

Discusses silting surveys of old and new lakes at Austin, and develops a theory of silting in New Lake Austin. The discussions by several well known engineers give considerable data on silting in various western reservoirs.

(88) ____
Silting of Reservoirs. Tex. Univ. Bull. 3025, 170 pp., illus. July 1930.

Contents: Silt; Silting of Old Lake Austin; Old Austin Dam and Its Failure; Silting of New Austin Lake; Silting of Lake McMillan; Silting of Zuni Reservoir; Silting in the Rio

(88) Continued.
Grande; Silting of Lake Worth; Silting of White Rock Reservoir; Silting of the Boyson Reservoir; Silting of Lake Penick; Silting on the Colorado of the West; Keokuk Reservoir; Water Dams; Silting of Lakes Wichita, Medina, Kemp, Lugert, and Garza; Desilting of Reservoirs and Canals.
The general occurrence of reservoir silting and its menace to water storage are emphasized.

(89) Towl, R. N.
Flood Regulation and Silt Control on the Silver Creek Floodway. Agr. Engin. 8: 334, illus. November 1927.

Describes the floodway on Silver Creek, near Tekamah, Nebr., and associated silting. Outlines plan for improvement by flooding an additional 200 acres of adjoining land, which will provide three outstanding benefits; namely flood control, silt control in the flood basin, and the return of clarified water to the main outlet which can thus carry more sediment from other sources. There will also be a benefit to the channel by increased duration of flow and decreased flood height.

(90) ____
Handling Silt in Settling Basins. Engin. and Contract. 62: 341-344, illus. August 13, 1924.

"The best settling basin is the natural one; where the overflow spreads out near the base of the debris or higher up, and flows out over the fan in a shallow, broad sheet. This quickly reduces the velocity and drops the silt, then the simple method of returning the flood waters to the channel of the ditch is accomplished by a pick-up ditch or a lateral..." Examples of floodway construction by silt deposits are cited, and a special design for economical construction of a floodway ditch is given. "We should have a better understanding of the causes of erosion and transportation of silt to the end that there may be more stabilized channels and reduced cost of maintenance."

(91) ____
Silt Control for Drainage and Flood Ditches. Agr. Engin. 8: 334, illus. December 1927.

The author enumerates 10 silt transportation factors in running water. "The foregoing general suggestions are important but by no means all-inclusive." That the primary

(91) Continued.
cause of floods in alluvial valleys is channel deterioration, caused by sedimentation, is affirmed.

(92) Twenhofel, William H.
Treatise on Sedimentation. 926 pp., illus. Baltimore, Williams & Wilkins Co. 1932.

Contents: Sources and Production of Sediments; The Transportation, Deposition, Diagenesis, and Lithification of Sediments; Important Conditions Modifying Sedimentary Processes; Sediments and Organisms; Products of Sedimentation; Structures, Textures, and Colors of Sediments; Environments or Realms of Sedimentation; Field and Laboratory Studies of Sediments.

(93) United States Bureau of Reclamation.
Bibliography on the Subject of Transportation of Solids by Flowing Water in Open Channels. 108 pp. 1933. (Mimeographed.)

"This bibliography has been compiled for the purpose of studying the silt and bed load problem in connection with the design of the All-American Canal... (it) has been made in two parts. Part I lists by authors all works thought to have any bearing on the general subject... Part II is a sub-classification by subject and the listing is by numbers referring to Part I."

(94) United States Congress.
Missouri River. 73d Cong. 2d sess., House Doc. 238: 1032-1182. 1935.

A comprehensive report on the Missouri River, containing a general plan for its improvement for purposes of navigation, water-power development, flood control, and irrigation. The main report includes brief discussions of suspended and bed loads and silting of reservoirs, including estimated rates of silting of potential reservoirs. Appendix XV discusses the origin, transportation, mechanical composition, weight, and specific gravity of suspended and bed sediment; river-bed changes; rate of silting in reservoirs and methods for its prevention or reduction; and erosion in over-flow areas.

(95) United States War Department, Corps of Engineers, United States Army.
Sediment Investigations on the Mississippi River and Its Tributaries Prior to 1930. U. S. Waterways Expt. Sta. Paper H: 1-84. July 1930.

Discusses methods of transportation of sedimentary material; outlines the history and description of investigations, dating from 1838; discusses the physics of sediment in suspension with regard to relationship between material in suspension and river stage, classification of sediment in motion, causes of suspension, changes in saturation due to local causes, and size of particles carried in suspension. Extensive data on results of sediment observations are tabulated.

(96) United States War Department, Corps of Engineers, United States Army.
Sediment Investigations on the Mississippi River and Its Tributaries, 1930-1931. U. S. Waterways Expt. Sta. Paper U: 1-105, illus. December 1931.

Contents: Purpose, to Determine the Amount of Sediment Carried in Suspension by the Mississippi River and Its Principal Tributaries; Observations on the Mississippi River, Its Upper Tributaries and Outlets; Observations on Tributary Rivers; Laboratory Analysis of Samples; Computation of Sediment Transportation Rate; Determination of Soil Volume Weights.
The results are summarized in tables and charts.

(97) United States War Department, Corps of Engineers, United States Army.
Studies of Materials in Suspension, Mississippi River. U. S. Waterways Expt. Sta. Tech. Memo. 122-1: 1-27, plus 11 tables and 83 plates. February 1, 1939.

A compilation of basic data collected to determine the quantity and characteristics of materials transported in suspension in the Mississippi River at all stages, and to measure the corresponding hydraulic elements. Data on depth, concentration of sand and silt in p.p.m. by weight, velocity, and temperature are tabulated.

(98) United States War Department, Corps of Engineers, United States Army.
Studies of River Bed Materials and Their Movement, with Special Reference to the Lower Mississippi River. U. S. Waterways Expt. Sta. Paper 18, 161 pp. January 1935.

Part I of this paper describes flume studies of river-bed materials to determine the effects of variation in composition of sediment, slopes of bed and water surface, and depth of water in flume. Part II gives results of a study of mechanical composition of 531 samples from the thalweg of the Mississippi River between Cairo and New Orleans and 143 samples from tributaries.

(99) Vetter, C. P.
Why Desilting Works for the All-American Canal? Engin. News-Rec. 118: 321-326, illus. March 4, 1937.

Discusses the transportation of suspended and bed-load sediment by the Colorado River, to justify the construction of the desilting works. Reviews investigations made to determine the probable amount of sediment that would be carried through the headgates of the diversion (Imperial) dam. These studies show that bed load is an insignificant factor in the lower Colorado, and that retrogression of the river bed below Boulder Dam is supplying most of the sediment. Comparison of various methods of silt removal indicates that the desilting works will be the most practical and economical method.

(100) Whitaker, R.
Silt-Sampling Apparatus Used on the Missouri River. Engin. News-Rec. 108: 395. March 17, 1932.

Describes the Au-type United States Geological Survey silt sampler, the Straub-type sampler, a hand-operated orange-peel bucket, and the Lugn cylindrical bed-sediment sampler used by the Silt Section of the United States Army Engineers Office at Kansas City, Missouri.

(101) Whitefield, A. F.
Some Practical Experiments in Silt Control. Agr. Engin. 9: 109-110, illus. April 1928.

An abstract of experiments on increasing soil fertility by flooding lands with silt-laden waters. Describes measures to reduce the required amount of sediment and to increase its quality, and gives results of experiments in increasing soil fertility with silt.